Initial RF Ingress Measurements for Coaxial and UTP Cables from Automotive BCI Test

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Outline

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- BCI Setup
- BCI test results (MDI voltage)
- Observations
- Setup for > 400 MHz
- Next Steps

Overview

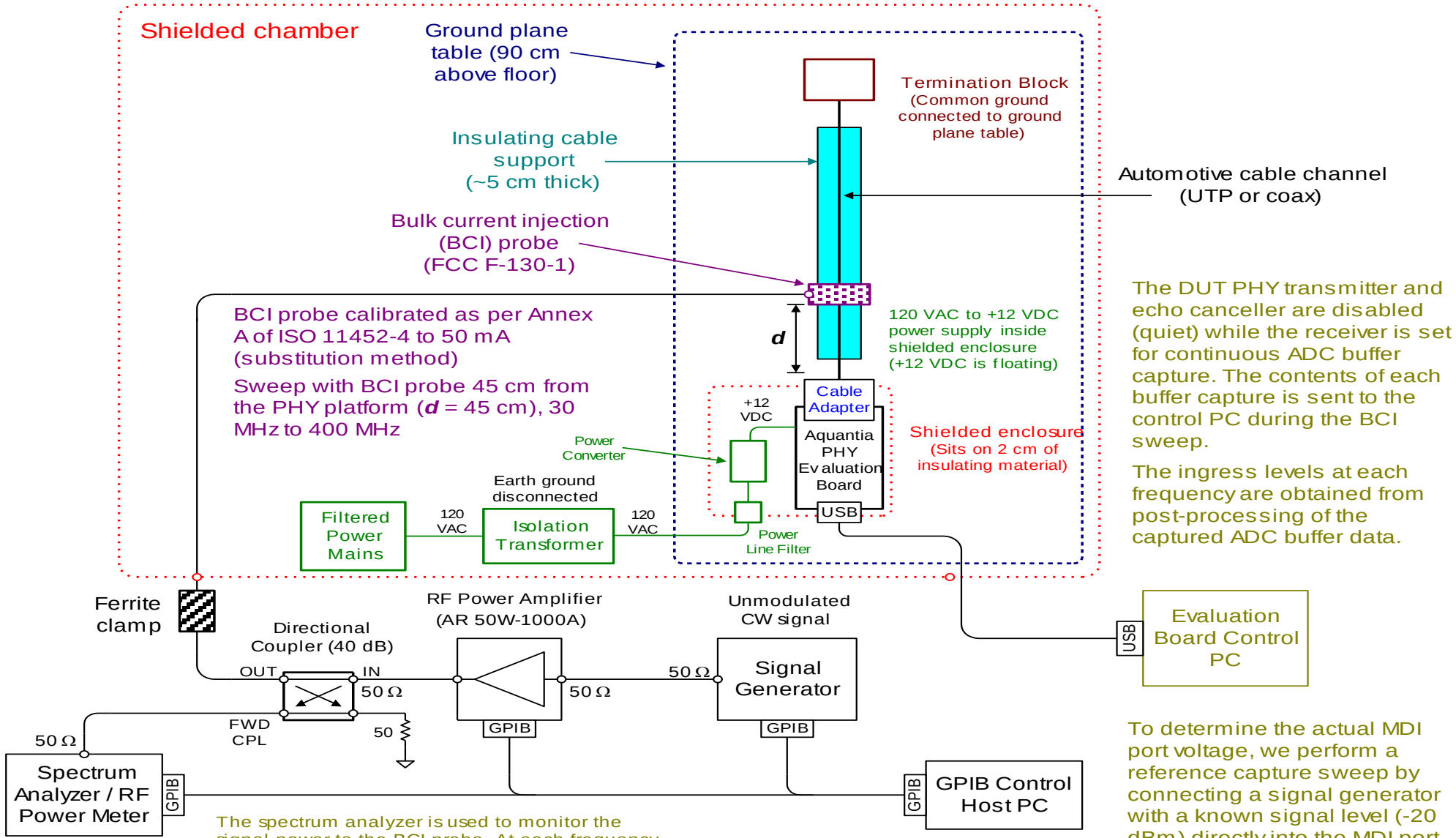
- Main Purpose: Initial measurement of the induced MDI port voltage from a standard automotive radiated immunity bulk current injection (BCI) test with different automotive harness cable types
  - BCI test method is defined in ISO 11452-4; this procedure is generally used only up to 400 MHz for testing RF immunity of cable harnesses
  - Test three different cable media:
    - Single-shield RG174 (1.9 meter sample)
    - PE-C100 (double-shielded RG174, 1.9 meter sample)
    - UTP (single pair in jacket, 5 meter sample)
  - All coaxial cable samples used FAKRA connectors

Procedure for Measurement of MDI Port Voltage from a BCI Test

- Perform the calibration procedure in Annex A of ISO 11452-4 to determine the required BCI probe input power to inject 50 mA of common-mode current at each frequency point (substitution method)
- Build the BCI test setup (page 4) with the automotive cable harness and connected to the far-end termination block; set the location of the BCI probe 45 cm from the MDI port
- Use the control PC to disable the evaluation platform PHY transmitter and echo canceller, set the PHY receiver gain blocks to known states, initiate continuous ADC buffer capture, and send the ADC buffer contents to the control PC over the USB
- Turn on the BCI drive amplifier and initiate the BCI frequency sweep; the sweep is from 33 MHz to 399 MHz at 2 MHz steps, dwell time of 2 seconds at each frequency point (after proper power leveling), test signal is an unmodulated CW signal
- When the BCI sweep is complete, apply post processing to the captured buffer data to determine the ADC capture level at each frequency point
- Connect an RF signal generator set at a known reference level (-20 dBm) to the MDI port and perform the same above sweep, buffer capture, and post processing to determine ADC capture level at each frequency point; this is the MDI port reference level sweep
- Determine the MDI port voltage from the BCI test by comparing and scaling the ADC capture levels from the BCI test to the corresponding data from the MDI port reference level sweep
- Scale the measured RF ingress voltage data to match a selected BCI test current condition template (e.g. GMW3097) with the difference between the test current level and test condition template and add any modulation level offset; plot the final result

- Note: The continuous ADC sample buffer procedure defined above does not require any synchronization connection with the EMC lab test equipment

Test Setup for BCI RF Ingress Measurement on Automotive Cable



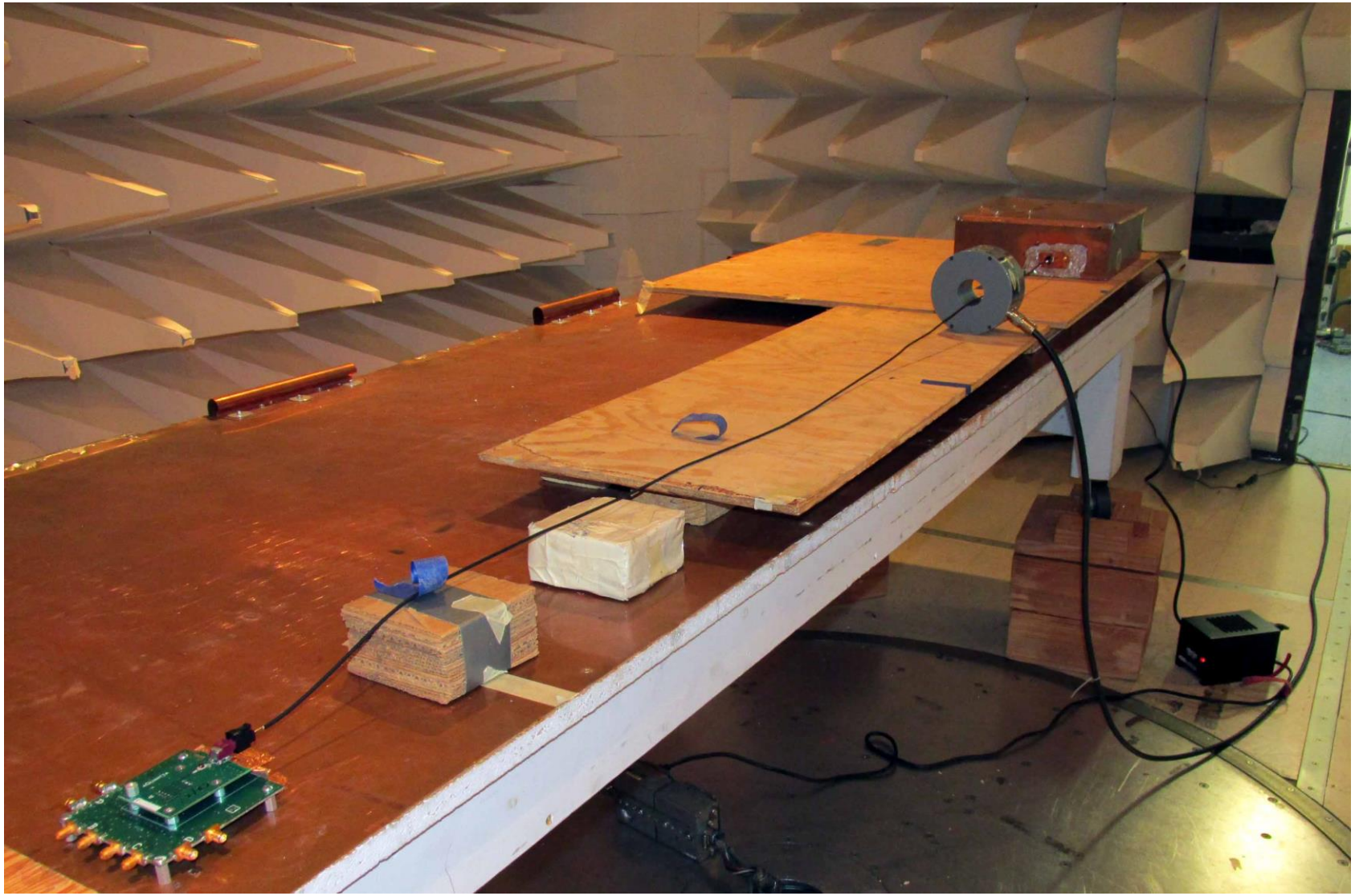
The spectrum analyzer is used to monitor the signal power to the BCI probe. At each frequency, the signal generator output is adjusted to match the calibration level at that frequency.

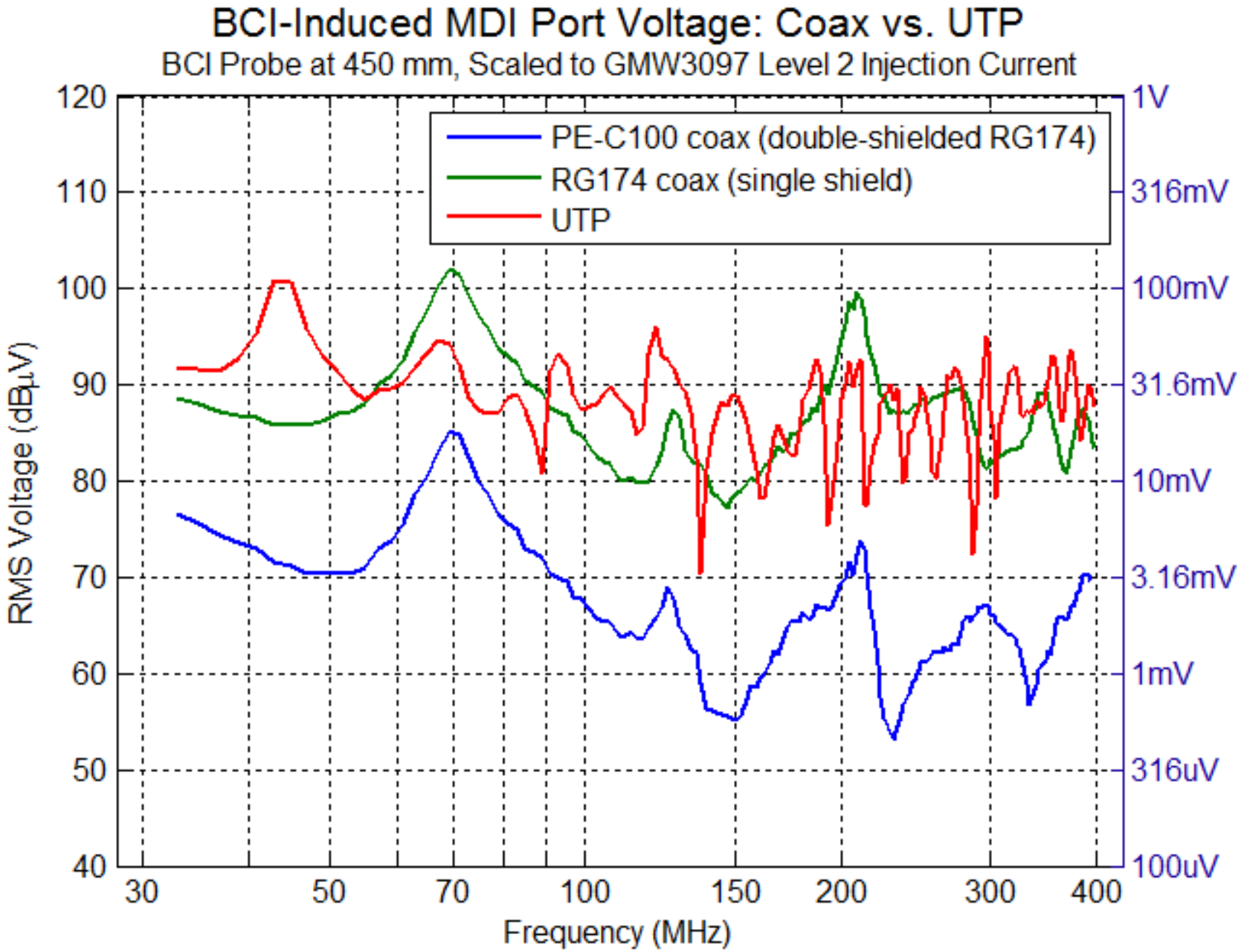
The DUT PHY transmitter and echo canceller are disabled (quiet) while the receiver is set for continuous ADC buffer capture. The contents of each buffer capture is sent to the control PC during the BCI sweep.

The ingress levels at each frequency are obtained from post-processing of the captured ADC buffer data.

To determine the actual MDI port voltage, we perform a reference capture sweep by connecting a signal generator with a known signal level (-20 dBm) directly into the MDI port of the Evaluation Board.

Test Setup for BCI RF Ingress Measurement on Automotive Cable




BCI-Induced MDI Port Voltage: Coax vs. UTP
BCI Probe at 450 mm, Scaled to GMW3097 Level 2 Injection Current
PE-C100 coax (double-shielded RG174)
RG174 coax (single shield)
UTP
RMS Voltage (dBµV)
Frequency (MHz)
120
110
100
90
80
70
60
50
40
30
50
70
100
150
200
300
400
1V
316mV
100mV
31.6mV
10mV
3.16mV
1mV
316uV
100uV

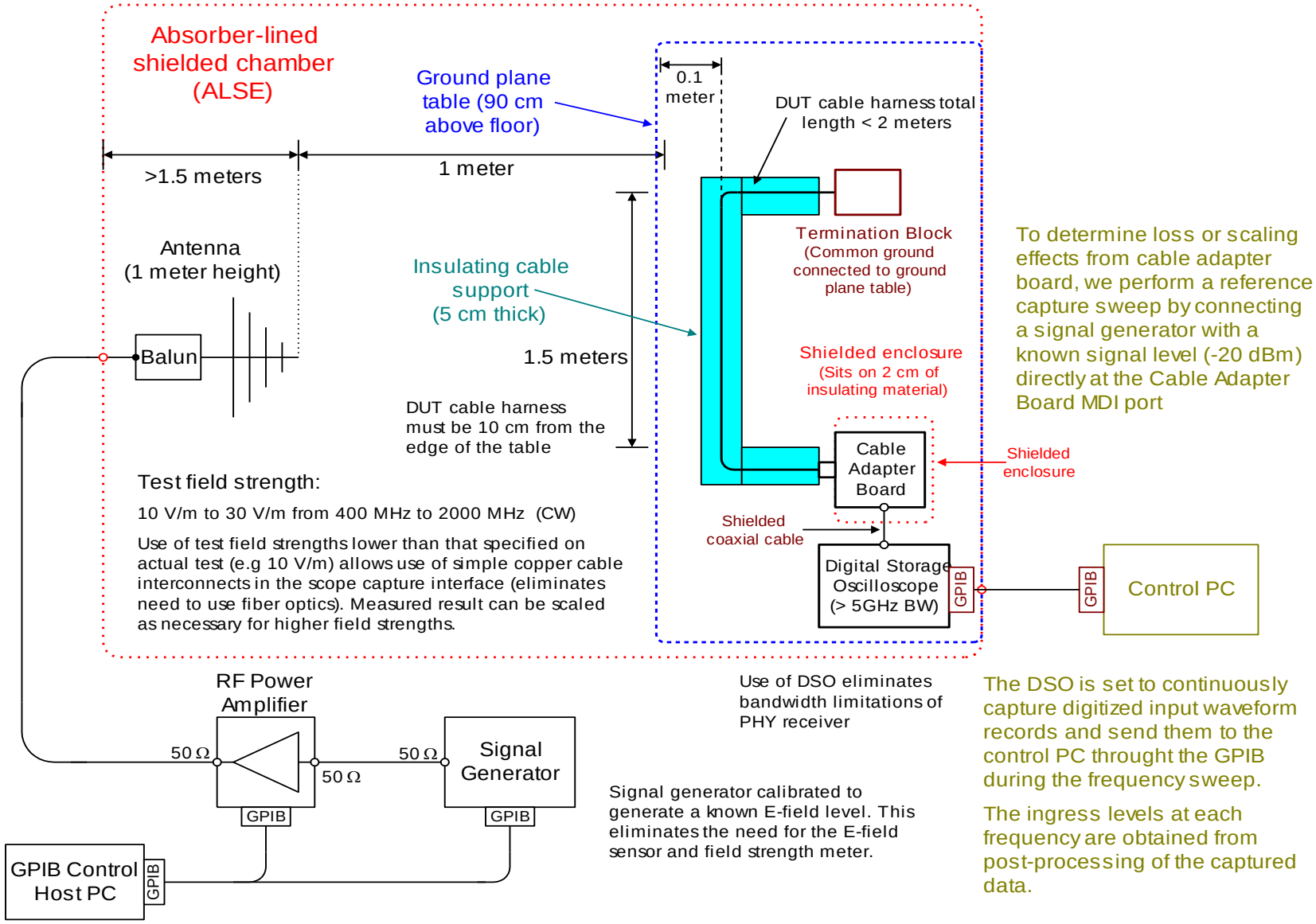
Observations

- The observed RF ingress coupling from single-shielded coaxial cable (RG174) is considerably worse than double-shielded coaxial cable (PE-C100) and actually on par with UTP cable
- The induced MDI port voltage with (double-shielded) coaxial cable is at least 20 dB less than the corresponding MDI port voltage with UTP cabling at most frequency points
  - Shield construction and termination matters !!
- The BCI test current was set at 50 mA to due to test equipment limitations
  - Use of reduced test currents simplifies test setup by allowing simple copper cable interconnects instead of fiber optics
  - This is permissible since we can simply scale the final measured results for a desired test template condition
- The different peak/null pattern in the UTP measurement is due to the longer cable sample that was tested (5m for UTP vs. 1.9m for coaxial cable samples)

Tests > 400 MHz

- Need to define a standard methodology to measure the RF ingress from different cable samples from 1 MHz to at least 3 GHz;
  - BCI test methods to 400 MHz as shown here
- Need radiative immunity test for higher frequencies
- Existing standard ALSE (ISO 11452-2) test methods are recommended

ALSE Test Setup to Measure RF Ingress from 400 MHz to 3 GHz



To determine loss or scaling effects from cable adapter board, we perform a reference capture sweep by connecting a signal generator with a known signal level (-20 dBm) directly at the Cable Adapter Board MDI port

The DSO is set to continuously capture digitized input waveform records and send them to the control PC throught the GPIB during the frequency sweep.

The ingress levels at each frequency are obtained from post-processing of the captured data.

Next Steps

- Identify cable samples for future testing:
  - STP cable, UTP cable in bundles
  - Automotive cable setup input appreciated from OEMs
- Perform RF ingress measurement on cable samples up to 3 GHz using the BCI tests as here + absorber-lined shielded enclosure (ALSE) methodology defined in ISO 11452-2

Thank you.